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Abstract

Our paper revisits the Marshallian inefficiency but from a different perspective in the presence of surplus labor in the farm household. We investigate the (in)efficiency of sharecropping relative to owner cultivation and fixed-rent cultivation in terms of total factor productivity (TFP), which is another important departure from the existing literature. We use an unbalanced panel dataset at the farm household level consisting of 4,206 rice cultivating plots for two major rice cropping seasons in Bangladesh. Our main identification strategy is based on a controlled experiment in which we take two plots cultivated by each farm household—one owned and another rented-in, either under a sharecropping or a fixed-rent contract. After controlling for time-varying household fixed effects, season fixed effects, plot-level characteristics such as soil quality, land elevation and provision for irrigation, and shocks that might damage crops, we find that TFP is about 4.2 percent lower in sharecropping than in owner cultivation, while there is no difference between fixed-rent and owner cultivation. It is labor than capital and material inputs per unit of land that is less intensively used in sharecropping plots. The important result is that the difference in TFP and labor use between sharecropping and owner cultivation decreases with the endowment of (male) working-age members at the household and ceases to exist after a threshold (3 or more working-age male members). Explanations of the results are discussed.

JEL Classification Codes: D24, J43, Q12, Q15.

Keywords: Marshallian inefficiency, Surplus labor, Total factor productivity, Sharecropping, Tenancy.

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1. Introduction

The formal analysis of sharecropping dates back to Alfred Marshall (1890), who described it as an inefficient institution. The Marshallian inefficiency is due to distorted incentives leading to suboptimal application of inputs as the sharecropper retains only a fraction of the surplus from employing additional inputs. The rental share that the sharecropper pays to the landlord is equivalent to a tax on her effort. In contrast, owner cultivation and fixed-rent contract, in which the tenant pays a fixed sum to the landlord and claims the residual, do not distort incentives.

There is a large literature on the (in)efficiency of sharecropping relative to owner cultivation and fixed-rent (for reviews, see Otsuka and Hayami, 1988; Singh, 1989; Quibria and Rashid, 1984; Otsuka, Chuma and Hayami, 1992; Deininger and Feder, 2001). However, the literature almost exclusively focuses on incentive provisions in the contract and information asymmetry to explain the relative efficiency. For example, the monitoring approach, pioneered by Cheung (1968, 1969) and later expanded by Stiglitz (1974), among others, argues that if the landlord can stipulate the plot size, tenant's share of output and intensity of inputs, and if she can monitor the stipulation effectively and costlessly, then sharecropping, owner cultivation with hiring wage workers and fixed-rent contract will be equally efficient.

Our paper revisits the Marshallian inefficiency but from a different perspective in the presence of surplus labor in the farm household. The concept of surplus labor was originally formalized by Lewis (1954) in the context of a dual economy consisting of an agrarian and a modern sector. The efficiency of sharecropping in the presence of surplus labor in an agrarian economy was raised by Sen (1962) and Mazumder (1975) but has not received attention. This idea can be simply formalized as follows. The optimal amount of family labor employed by a sharecropper is determined by equating the marginal product of labor (MPN) she retains with the competitive market (real) wage. However, in the presence of surplus family labor with limited (or no) outside options, she equates her retained MPN with the shadow wage of family labor, which is less than the competitive market wage (Georgescu-Roegen, 1960; Sen, 1962; Mazumder, 1975; Quibria and Rashid, 1984). Therefore, the optimal amount of labor employed by a sharecropper having surplus family labor would be higher than what would have otherwise been. If the shadow wage is decreasing with the amount of surplus family labor, the gap between the optimal amount of labor supplied by a sharecropper and that by an owner cultivator or a fixed-renter will also be shrinking with the gap disappearing when shadow wage approaches zero.

It is important to mention that because of the seasonality of labor requirement in agricultural production the gap between the market wage and shadow wage of family labor may not necessarily exist over the entire production period. For example, the gap may not exist in the peak period (activities such as planting and harvesting which must be done within a short window) when labor demand is high but does exist in the off-peak period (activities such as weeding, applying fertilizers and insecticides) when labor demand is low. When aggregated over the production period, there must be a gap between the two prices (Mazumder, 1975).

Empirical investigation of the Marshallian inefficiency compares yields (output per unit of land) in sharecropping, owner cultivation and fixed-rent. However, the literature lacks consensus on the support of the inefficiency hypothesis (Otsuka and Hayami, 1988). Endogeneity of contract choice is a key challenge to separate the effect of tenurial contracts from many unobservable factors. Some studies (for example, Rao, 1971; Bell, 1977; Shaban, 1987; Laffont and Matoussi, 1995; Jacoby and Mansuri, 2008) explicitly addressed the identification issue and found that the yield is lower in sharecropping than in owner cultivation and fixed-rent, and sharecroppers employ less labor and other inputs than owner cultivators and fixed-renters.[1]

Our paper also departs from the extant literature in another important dimension. We compare efficiency in terms of total factor productivity (TFP), which is the efficiency of a farmer to produce an amount of output with a given set of inputs. In contrast, yield, the conventional measure of productivity employed in both theoretical and empirical literature on sharecropping, is a partial measure of productivity; more specifically, it is the average product of land. If yield differs across farmers because of different intensity of labor use with all other factors of production remaining the same, the average (and marginal) product of labor will also differ across farmers that needs to be taken into consideration when comparing efficiency. Additionally, the negative size-productivity (yield) relationship[2] documented in the literature (see, Otsuka, 2007 for a nice discussion), which is also advocated as a reason for land reform, is biased because of its failure to account for returns-to-scale departing from unity and market imperfections that alter input combinations. TFP as the measure of

[1] The inefficiency of sharecropping has been reported in the context of Bangladesh by Mandal (1980), Talukdar (1980), Shahid and Herdt (1982), Bhuiyan (1987) and Bidisha, Hossain, Alam and Hasan (2018).

[2] One of the reasons for the inverse size-productivity (yield) relationship is that small farmers, who depend more on family labor, employ more labor per unit of land (Otsuka, 2007).

productivity overcomes these limitations, and the size-productivity (TFP) relationship becomes positive (Helfand and Taylor, 2021; Aragón, Restuccia and Rud, 2022).[3] This size-productivity relationship is crucial for comparing efficiency if the sizes of the owner and tenant-cultivated plots vary significantly.

Specifically, we investigate the existence of the Marshallian inefficiency by comparing TFP differences of sharecropping with owner cultivation and fixed-rent, and whether this inefficiency, if exists, disappears when there is surplus labor in the farm household. Our context is rice cultivation in Bangladesh. *Given that rice is cultivated as a monocrop in Bangladesh,*[4] *we are able to separate the Marshallian inefficiency from the differences in production function* (Hayami and Otsuka, 1993).[5] In Bangladesh, rice is grown in about 75% of the total cropped area and almost all farm households grow rice, contributing to about 48% of rural employment.

Our empirical analyses use an unbalanced panel dataset at the farm household level consisting of 4,206 rice cultivating plots for two major rice cropping seasons, *Amon* and *Boro*, in 2012 and 2014 (a total of four season-years). Detail information was collected about output, inputs and their prices, plot-level characteristics such as soil quality, land elevation and provision for irrigation, and also shocks that might damage crops. Our main identification strategy is based on a controlled experiment, employed by Shaban (1987), among others, in which we take two plots cultivated by each farm household—one owned and another rented-in, either under a sharecropping or a fixed-rent contract. Tenancy contracts are endogenously determined by farmer characteristics, many of which are unobserved. For example, a tenancy contract acts as a self-selection device, in addition to an incentive device, to identify the characteristics of different individuals (Newbery and Stiglitz 1979). In the absence of insurance market, a more risk-averse (and less productive) individual will prefer a sharecropping than a fixed-rent contract. Our identification strategy addresses

[3] A proportional farm size productivity relationship is required for efficient factor allocation that maximizes aggregate output in the presence of heterogeneous farmers (Chen, Restuccia and Santaeulàlia-Llopis, 2023).

[4] Even a specific variety of rice is cultivated as a monocrop. In our data, (specific variety of) rice is monocropped in about 88 percent of all plots, which we retain in our sample. The rest are multiple-cropped plots where rice was not cultivated.

[5] Hayami and Otsuka (1993) compare the difference in output per unit of land of sharecropping from that of owner cultivation from 32 studies and found that the mean rate difference is not significantly different from zero in the case of single-crop output. But if the total output (of all crops) per unit of land is compared, the mean rate of difference is significantly lower in sharecropping supporting the Marshallian inefficiency. They conclude that this difference is due mainly to production functions than suboptimal use of labor input.

the unobserved heterogeneity across farmers. Recently, concerns have been raised that this strategy does not fully account for the endogeneity of contract choice and plot-level characteristics (Arcand, Ai and Either, 2007; Braido, 2008; Jacoby and Mansuri, 2009; Burchardi, Gulesci, Lerva and Sulaiman, 2019). Contract choice might also be determined by plot-level characteristics. Our rich data allows us to control for time-varying farm household fixed effects, season fixed effects and plot-level characteristics that overcome the above concerns.

We find that TFP is about 4.2 percent lower in sharecropping than in owner cultivation, while there is no difference between fixed-rent and owner cultivation. These results are robust in several ways that include TFP calculated in alternative methods and using different combinations of the control variables, including household and season fixed effects. Importantly, we find that these results crucially depend on accounting for the size-productivity relationship. The reason for lower TFP in sharecropping is due mainly to less intensive use of labor rather than capital and material inputs per unit of land. About 12% less labor per unit of land (5.4 person-days per acre of land) is employed in sharecropping than owner cultivation compared to 1.8% and 3% less capital and material inputs. The reasons for the latter results are that indivisible capital service (which mostly consists of mechanized tilling by small power-tillers) is purchased from external service providers by almost all farmers and availability of inputs, especially fertilizers, at a subsidized price. When total labor is disaggregated by family and hired labor, it is the family labor that is employed less intensively (6.3 person-days per acre of land). Hired labor is employed less at the extensive margin but there is no difference in the intensive margin.

Empirical examination of the effect of surplus labor on Marshallian inefficiency because of the lack of a workable definition of surplus labor. Surplus labor in an agrarian economy is defined as the part of the labor force that can be removed without reducing the total amount of output produced (Lewis, 1954; Sen, 1966), which is difficult to operationalize in empirical estimation. Given this limitation, we follow an indirect approach, à la Chay and Munshi (2015), to compare TFP and labor intensity (labor per unit of land) between sharecropping and owner cultivation as the amount of labor endowment in a farm household increases. More specifically, we take each value of the labor endowment in the data range as a threshold and test if the difference in TFP and labor intensity ceases to exist at and beyond the threshold. Our proxies for labor endowment are the number of male working-age members and the number of gender-adjusted (male equivalent) working-age members in a farm household both aged between 15 and 64 years. We find that the difference in TFP between sharecropping and owner cultivation ceases to exist when there are three (3.2) or more working-age male (male equivalent) members in the household. In the case of labor use, these thresholds of labor endowment are three and 4.1, respectively. Similar results are obtained for family labor use. These results provide support for our model that the Marshallian inefficiency ceases to exist in the presence of surplus labor.

The rest of the paper is organized as follows. Section 2 describes the agrarian relationship, rice cultivation and tenancy in Bangladesh. Section 3 describes the data and discusses some key descriptive statistics. The relevance of TFP as a measure of farm productivity and its measurement is discussed in Section 4. Estimation strategy including the identification is discussed in Section 5. The results for the Marshallian inefficiency and that in the presence of surplus labor are presented in Section 6 and 7, respectively. Finally, Section 8 concludes.

2. Background

2.1 Changes in agrarian relationship

The agrarian relationship in Bangladesh has followed a new trajectory since 1990s which is referred to as the '*hybrid Bangladeshi*' model by Wood and Mandal (2022).[6] This is characterized by leasing-out land to small and landless farmers along with commercialization of agricultural services. This enhances consolidated operation and efficiency gains while maintaining the historical attachment to land.

One unique pattern of landholding in Bangladesh, even those of large landowners, is that plots are fragmented, spatially scattered and of small size.[7] The average size of a plot is only 29.65 decimal (Rahman, 2010). With the advent of mechanization and spread of modern agricultural technologies (Green Revolution), this pattern caused managerial difficulty for large (and medium) landowners to cultivate all their plots and forced them to rent out land in excess of their own direct cultivation capacity to small and landless farmers. Mechanization involves replacing bullock ploughing (which has almost disappeared), manual threshing and, to some extent, harvesting by machine. Mechanical ploughing invariably consists of ploughing by power-tillers because power-tillers, unlike tractors, are easier to move between

[6] The following discussions are drawn on Wood and Mandal (2022).

[7] Rahman and Rahman (2009) reported that in their sample from the Barisal district in Bangladesh the average level of land fragmentation is 4.4 with a range from a single plot farm to a maximum of a 21-plot farm. They estimated that a one percent increase in land fragmentation reduces rice output by 0.05% and efficiency by 0.03%.

fragmented plots. For the same reason, small harvester, instead of lumpy combined harvester, has become popular.

However, renters and small farmers are now less dependent on larger farmers, who are also rentiers, for access to credit and inputs. They have access to credit through microfinance institutions, and (subsidized) inputs through the government. Ploughing by power-tillers, harvesting and irrigation services are provided by local service providers who are themselves landholding farmers within local communities and constitute about 10 percent of the total farm households. They offer services to other majority farmers in addition to cultivating their own and/or leased-in lands.

Even with increasing capital intensity in agricultural production, demand for labor has also increased. This is due to the increase in input intensity and better crop care, which is also a result of the expansion of HYV. For example, the tasks of planting, weeding and application of fertilizer and pesticides are done by manual labor.[8] Both owner cultivators and renters more or less hire agricultural workers on a daily basis, in addition to employing family labor, during the peak period of planting and harvesting when the demand for labor is high because these tasks must be completed within a very short window.

These developments have important implications for the productivity of owner cultivators and tenants. Since both rely on external service providers for lumpy capital, there is (almost) no variation in capital use between them. In contrast, application of divisible inputs, such as (family) labor and material inputs, varies between them depending on incentive provisions in the contract.

2.2 Rice Cultivation

Rice plays a vital role in the livelihood of the people of Bangladesh. It is the staple food providing about two-thirds of total calorie intake and about one-half of the total protein intake of an average person. Rice monocropping is the dominant cropping pattern in Bangladesh. Almost all farm households grow rice contributing to about 48% of rural

[8] Based on the information from Bangladesh Agricultural Research Council (BARC), Bangladesh Rice Research Institute (BRRI), Department of Agriculture of the Government of Bangladesh and Bangladesh Agricultural University, Hossen (2019; Table-1) estimated capital and labor intensities in different activities in agricultural production in Bangladesh. Activities are either almost entirely capital- or labor-intensive. For example, capital intensity is the largest in land preparation (98%), followed by threshing (97%) and pesticide / herbicide application (92%). On the other hand, labor intensity is the largest in planting and fertilizer use (95%) followed by harvesting (93%) and weeding (92%).

employment and one-sixth of the national income. Rice is grown on about 75% of total cropped area and has remained almost stable over the past three decades.[9]

There are three rice growing seasons in Bangladesh, namely *Amon*, *Boro* and *Aus*, with the first two being the dominant seasons. In 2022-23, Amon was cultivated in 49.2% of total land under rice cultivation, contributing to 39.5% of total rice production. Boro was cultivated in 41.7% of total land under rice cultivation contributing to 53.1% of total rice production. In contrast, Aus was cultivated in only 9.1% of land under rice cultivation contributing to 7.4% of total rice production (Authors' calculation from Table 2.1.1 in BBS, 2024). Between the 1984-85 and 2012-13 periods (at the time of the surveys for our study), the amount of land area cultivated for Boro rice has increased by 202% and production has increased by 380%. During this period, the amount of area cultivated for Aman remained almost the same while production has increased by 64%. On the other hand, the amount of land area cultivated for, and production of, Aus rice decreased by 64% and 16%, respectively (Authors' calculation from Table 2.2.1 in BBS, 2016).

There are two broad varieties of rice cultivated in Bangladesh, namely *local* and *modern*.[10] Modern Boro varieties constitute of *hybrid* and *HYV*,[11] while modern Amon varieties consist mainly of HYV. Local varieties of Boro are planted in December-January and harvested in April-May. Modern varieties of Boro are planted in mid-December-February and harvested in May-June. Both local and HYV varieties of Amon are planted in July-August and harvested in November-December. Aus is planted in April-May and harvested in June-July.

Cultivation of local varieties of Boro has become almost extinct; in 2012-13 the share of modern (HYV + hybrid) Boro constituted 98.6% of land and 99.3% of production of Boro rice. In contrast, the share of HYV Amon constituted 70% of land and 80.9% of production of Amon rice (BBS, 2016). Modern varieties, although costlier for production than local

[9] Source: Bangladesh Rice Knowledge Bank, Bangladesh Rice Research Institute (BRRI); https://www.knowledgebank-brri.org/riceinban.php (access on October 03, 2024).

[10] Compared to local varieties, modern varieties are dwarf, sturdy and high yielding and have better grain quality and early maturity. Source: (http://www.knowledgebank.irri.org/images/docs/boro-rice-and-opportunity-for-intensification.pdf; accessed on October 03, 2024).

[11] According to Rice Knowledge Bank of IRRI, a hybrid is the product of a cross between two genetically distinct rice parents. When the right parents are selected, the hybrid will have both greater vigor and yield than either of the parents. It is also more resistant to diseases and insects. But its seeds are expensive and farmers cannot not preserve seeds. HYV is also genetically engineered but is made with the focus on high yield. Source: (http://www.knowledgebank.irri.org/training/fact-sheets/crop-establishment/item/hybrid-rice-fact-sheet; accessed on October 03, 2024)

varieties because these require more irrigation, labor, and use of machineries and materials such as fertilizers, have higher yield (output per acre of land) making them more profitable (Rahman and Connor, 2022). However, consumers prefer local varieties of rice because of their better taste (Tenriawaru et al., 2023), and these are usually cultivated by farm households having more non-farm income (Rahman and Connor, 2022).

2.3 Farm households and tenancy

Farm holdings, defined in BBS (2022) as "an agricultural production unit having cultivated land equal to or more than 0.05 acres," constitute 53.9% of all (farm and non-farm) holdings. Small farm holdings (having 0.05-2.49 acres of cultivated land) are predominant constituting 91.9% of all farm holdings, *which are the population in our study* (see Section 3). Medium (having 2.50-7.49 acres of cultivated land) and large (having 7.50 acres or more cultivated land) farm holdings constitute 7.5% and 0.60%, respectively. In terms of land operation,[12] small, medium and large farm holdings operate 69.7%, 23.6% and 6.7% of land, respectively (authors' calculation from Table 23, BBS, 2022).

Among small farm households, 64.3% own cultivable land who are either owner cultivators or rentiers, 2.3% are (pure) tenants who are renters and do not own land, and 33.4% are mixed-tenants (tenant-cum-owner) who are both owner-cultivators and renters (a negligible percent are rentiers).[13] There has been a change over time in the patterns of tenurial contracts. Based on the two previous agricultural censuses in 1983-84 and 2008, Hossain, Malek and Das (2014) document that the prevalence of sharecropping has decreased and that of fixed-rent and other long-term contracts have increased. For example, fraction of sharecroppers (land under sharecropping) among all tenants has decreased from 70.2% (74%) to 43% (41.3%), while that of fixed-renters (land under fixed-rent) has increased from 10% (10.1%) to 25.3% (23.8%). Although declining, sharecropping still remains the predominant form of tenancy in Bangladesh (this is also consistent with our data; see Section 3). In terms of land operation, the share of rented-in land in total cultivated land increased from only 23.4% in 1988 to 32.9% in 2000 to 45% in 2014 (Sen et al., 2023).

[12] (Total) operated area "equals to area owned plus land taken from others minus owned area given to others" (BBS, 2022).

[13] Overall farm holding characteristics are similar to those of small farm holdings because of the predominance of the latter group. For example, of all farm households, 64.3% constitute owners, 2.3% constitute (pure) tenants, and 33.4% constitute mixed-tenants. These shares have also remained almost the same since 1983-84 when share of owner cultivators was around 63% and that of mixed-tenants was around 36% (Hossain, Malek and Das, 2014).

The amount of land operated per farm household in Bangladesh is very small at 1.29 acres. The net cultivated area, defined as where *temporary crops*[14] are grown, is only 0.97 acres per farm household. About 26% of households in Bangladesh are "agriculture labor households" defined as those households whose member(s) work for others for wages and their main income source is agricultural wage (BBS, 2022).

3. Data

Data comes from the BRAC Tenant Farmer Development Program (BCUP— *Borga Chashi Unnayan Prakalpa* in Bengali) in Bangladesh. Given the limitations of formal banks and microcredit institutions in providing credit to small and marginal tenant farmers, Bangladesh Bank (the central bank of Bangladesh) and BRAC collaboratively implemented the BCUP, which is a customized credit program aimed at providing soft loans to small and marginal tenant farmers at a 10% flat interest rate. The program was incepted in 2009, and till 2015 it covered 212 *Upazilas* (subdistricts) in 46 out of 64 districts.

A three-stage random sampling technique was used to select the sample. In the first stage, BRAC branch offices (which are usually located at the *Upazila* headquarters) were chosen from a list of potential locations where the BCUP had planned to expand. From this list, 40 branch offices were randomly selected, which covered 40 *Upazilas* in 22 districts.

In the second stage, a list of all villages within an eight-kilometer radius of the selected branch offices was prepared. From this list, six villages under each branch office were randomly selected totaling 240 villages. A household census was conducted in all selected villages that covered 61,322 households. Among these households, 7,563 households met the selection criteria for the BCUP program: i) possession of a national ID card, ii) the farmer's[15] age between 18 and 60 years, iii) educational qualification of secondary school certificate (year 10) or below, iv) maximum landholdings of 200 decimals, v) not being a member of a microfinance institution and vi) willingness to participate in the BCUP.

Finally, 4,301 households were randomly selected for the BCUP out of the 7,563 eligible households.[16] The baseline (first-round) survey was conducted from early June to

[14] Defined as "crops with less than one-year growing cycle" (BBS, 2022).
[15] The BCUP defined a farmer as a person who is directly engaged (primary occupation) in agricultural production. In the case of multiple farmers in a household, the senior most person is considered.

[16] A randomization was done at the village level with 2,155 treatment and 2,146 control farmers (farm households). Since our paper is not related to investigating any impact of the BCUP intervention, we do not discuss the details of the randomization. However, it is important to mention that only 20% of the treatment farmers received credit from the BCUP. In the endline survey, 4,100 households could be traced for interview.

early August in 2012 before the program intervention, and the follow-up survey was conducted from mid-June to mid-August in 2014. Data in both rounds was collected through in-person interviews using an identical structured questionnaire.

To understand how our sample represents the rural farm household population in Bangladesh, we compare some key characteristics of all households in the village census and the BCUP-eligible farm households from which our sample was drawn. Differences in age, years of schooling, farming experience of the farmer, household size and ownership of cultivable land are small between the two groups although statistically significant because of very large sample sizes. For example, the average years of farming experience is 22.1 years for the BCUP eligible farmers compared to 23.8 years in the population. The amount of cultivable land owned for these two groups are 37.86 and 33.84 decimals, respectively. The main difference is in the amount of rented-in land that is almost double for the BCUP eligible households, which is due to the nature of the targeting in the BCUP. This difference is also reflected in the total amount of land cultivated.

Insert Table 1 here

Detail output and input data for the two largest plots, one owned and another rented-in, for each of the Amon and Boro seasons was collected giving the information for four season-years. However, many households, who did not cultivate two such plots in a given season-year, are excluded from our sample. We also retain the plots cultivating rice. This leads to an unbalanced panel of 4,206 plots cultivated by 1,225 households. Out of these plots, 2,146 are in 2012 and the rest are in 2014; season-wise, there are 1,800 plots in the Amon season and the rest are in the Boro season. By the research design, half of these plots are owner cultivated; 1,239 (29.46%) plots are under sharecropping contract and 864 (20.54%) plots are under fixed-rent contract (either crop or cash). It is important to mention that the largest plots (owned and rented-in) cultivated by a household are not necessarily the same in each season-year. Therefore, the plot identifier was not maintained in either survey.

Output information includes the specific variety of rice cultivated, quantity and farmgate price of rice produced (harvested) and the farmgate value of hay, which is a by-product after threshing paddy from the plant (used as fodder for cattle). Total farmgate value is calculated by adding farmgate values of rice and hay. Finally, the real quantity is calculated by deflating the total farmgate value by the (season-year at the district-level) average farmgate price of the rice variety produced in most plots.

Plot level information reported by the farmer includes its size (in decimal), soil type (e.g., loam, clay, sandy, sandy-loam and clay-loam), land elevation (e.g., high, medium-high, low and very low) and provision for irrigation (e.g., no provision, irrigation done manually, by Low Lift Pump, Shallow Tube Well or Deep Tube Well, and provided by Water Development Board).

The main expenditure for capital is tilling. In almost all plots (about 99%), tilling is done using power-tillers. Tilling is purchased from the external service providers in 91.13% of the plots and is done using owned power-tillers in the remaining plots. In the latter case, these farmers are the external service providers and information was collected about their imputed cost of tilling (How much the farmer would charge if he sold this amount of tilling service to others?). In about one percent of the plots, tilling is done by contractual ploughing by cows for which the total ploughing cost was collected.

Irrigation was done in 59.8% of all plots. Among the irrigated plots, contractual irrigation was purchased from the external service providers in 45% of the plots. In the remaining plots, irrigation was conducted by the farmer and the imputed cost of contractual irrigation was collected (How much the farmer would charge if he sold this amount of irrigation service to others?). The predominant modes of irrigation are Shallow Tube Well, Low Lift Pump and Deep Tube Well that constituted 97% of all irrigated plots. Costs for threshing paddy using thresher or power-tiller was calculated in a similar way. For manual threshing, information about number of person-days employed was collected, which was added to labor input. Costs of tilling, irrigation and threshing are added to calculate the total capital expenditure.

Materials (intermediate) inputs include seed, seedling, fertilizer (TSP, urea, potash, DAP, NKPS), cow dung / green manure, herbicide and pesticides. For each of these items, information about both quantity and purchase value was collected. Total material costs are the sum of the above costs including transportation costs from the market. If cow dung / green manure was used from own stock, market value of the quantity was calculated using the market price. Total expenditure is deflated by the price of TSP (by season-year), which constitutes the largest share of total material costs.

Labor employment, both family and hired, for each stage of production that includes germinating seeds, preparing the bed, planting, weeding, using fertilizers, harvesting and threshing was collected in terms of person-days. For hired labor, wage payment was also collected. Imputed wage payment for family labor at the market wage rate was also collected.

However, labor use disaggregated by gender was not collected given that it is predominantly male labor that is used in rice cultivation (see more in Section 6.3).

Farmers reported shocks in 23% of the plots that damaged crops. The main reasons are insecticides (11.65%) followed by drought (4%), hailstorm (2.34%) and flood (2.17%); insecticides and hailstorm are more idiosyncratic (plot specific) than drought and flood, which affects crops in all plots in a village. There may be a possibility that the respondents might misreport crop damage in one type of plot than the other. Of all plots in which any crop damage was reported, 48.9% are owner cultivated. Given that half of the sample plots are owner cultivated, the reported crop damage are almost equally divided between owner cultivated and rent-in plots. However, of the rent-in plots in which any crop damage was reported, 64.7% are under sharecropping contracts but sharecropping constitute 58.9% of all rent-in plots. Therefore, crop damage was reported at a slightly higher rate in sharecropping than in fixed-rent plots. Farmers also reported their perceived amount of crop damage but we have not adjusted the quantity of rice harvested. We only include dummies for these shocks in our regressions.

3.1 Descriptive statistics

By our research design, there is no difference in demographic, socioeconomic or other characteristics between owner cultivators and tenants. More importantly, these are captured by household fixed effects in our regressions. Here, we discuss the selected characteristics that will be found to be important in subsequent analyses. The average number working-age members aged between 15-65 years is 2.49 and when disaggregated by gender these are 1.25 and 1.24 for male and female, respectively. The average household size is 5.09. There is no difference in these demographic characteristics between sharecropper and fixed-renter households.

The differences that are of interest are the plot level characteristics. Table 2 summarizes plot size by owner and tenant cultivation both in terms of absolute size (cols. 1-3) and logarithm that gives percentage difference (col. 4). The average size of owner-cultivated plots is 26.2 decimal. The average sizes are larger for sharecropping and fixed-rent plots by 14.2 and 12.2 decimal, respectively (col. 1). These differences do not change after adjusting soil quality, land elevation, provision of irrigation, and season and year fixed effects (col. 2). These do not also change after additionally controlling for farm household fixed effects (col. 3). In terms of percentage difference, these are 47% and 38%, respectively (col. 4). This result is perhaps due to the fact that the tenant households are usually small farmers who own plots of smaller size than the plots they rent in from the rentiers who are large landowners (see, footnote 19).

Insert Tables 2 and 3 here

Table 3 summarizes rice varieties (modern vs local) cultivated in owner and tenant cultivated plots. Modern varieties are cultivated more by 5.6% in sharecropping than owner-cultivated plots, while local varieties are cultivated more by 7.2% in fixed-rent than owner-cultivated plots (col. 1). These differences narrow down after controlling for plot size and characteristics and season and year fixed effects (col. 2). When farm household fixed effects are additionally controlled for, there is no difference in the cultivation of modern varieties between sharecropping and owner-cultivated plots, and local varieties are cultivated in fixed-rent plots more only by 1.8% (col. 3).

4. TFP as a measure of farm productivity

The Marshallian inefficiency was originally formulated and subsequently investigated by comparing yields (output per unit of land) between sharecropping and owner cultivation. But yield is a partial measure of productivity; more specifically, it is the average product of land. In contrast, TFP captures the returns to all factors of production; alternatively, the efficiency of a farmer to produce an amount of output with a given set of inputs. If yield differs because different farmers employ different amount of labor with all other factors of production remaining the same, their average (and marginal) product of labor will also differ that needs to be taken into consideration when comparing efficiency. This argument applies to other inputs as well. Therefore, farmer's efficiency must be compared by whether the same (more) output can be produced using less (the same amount of) inputs. This is important when farmers encounter imperfections in input, credit and output markets, which will lead to suboptimal input combination that also differ across farmers (Townsend, Kirsten and Vink, 1998; Aragón, Restuccia and Rud, 2022).

Our benchmark measure of TFP is calculated using parameterization in the following Cobb-Douglas production. A Lucas-type span-of-control production function with decreasing returns to scale in inputs is given by (ignoring plot subscript):

$$y = A^{1-\gamma}\left[\left(k^{\alpha}l^{\beta}n^{1-\alpha-\beta}\right)^{1-\theta}m^{\theta}\right]^{\gamma} \qquad \text{---(1)}$$

Here, y is the amount of gross real output,[17] k is the value of capital services, l is the amount of (quality-adjusted) land, n is the amount of labor (in person-days), and m is the amount of material (intermediate) inputs used in production. TFP is given by $A^{1-\gamma}$. The returns-to-scale parameter is set at $\gamma = 0.85$ (following Brandt, Ayerst and Restuccia, 2018), which is the sum of the factor income shares. Sharecropping is the dominant form of tenancy in Bangladesh; in our data, 59% of all rented-in plots are under sharecropping contract and about 84% of sharecropping contracts are based on 50-50 output sharing (without sharing inputs). Therefore, the land share of output is set at 0.50. Both labor and capital shares are set at 0.14 and the material input share is set at 0.07. These lead to $\alpha = 0.179$; $\beta = 0.641$; $\theta = 0.082$.

It is important to mention that our main results of the percentage difference in TFP of sharecropping with owner cultivation and fixed-rent are almost invariant to alternative parameterization. However, it affects the results for the counterfactual aggregate output gain if resources are reallocated from tenant cultivation to owner cultivation (Section 7).

For robustness check, we calculate TFP alternatively by estimating variants of equation (1): i) the log-linearized Cobb-Doughlas production function, ii) a second-order Taylor approximation of the CES production function (Kmenta, 1967) and iii) the translog production function.

5. Estimating equation and identification

5.1 Estimating equation

We estimate the following equation to obtain the difference in TFP of owner cultivation with sharecropping and fixed-rent.

$$\ln TFP_{pist} = \alpha + \eta_{it} + \gamma_s + \beta_1 S_{pist} + \beta_2 F_{pist} + \delta_1 \ln L_{pist} + \delta_2 RV_{pist} + \mathbf{\Psi}'\mathbf{V_{ist}} + \boldsymbol{\psi}'\mathbf{W_{pist}} + \varepsilon_{pist} \qquad \text{-----(2)}$$

Here, $\ln TFP_{pist}$ is the logarithm of TFP, which is our measure of productivity, in plot p cultivated by farm household i in season s of year t, S is the dummy if the plot is cultivated under sharecropping contract, F is the dummy if the plot is cultivated under fixed-rent contract (owner cultivated plot is the base category), L is the plot size in decimal, RV is the dummy for rice variety (=1 if modern variety—*HYV* or hybrid; 0 if local variety), η_{it} is the time-varying farm household fixed effects and γ_s is the (cropping) season fixed effect. **V** is a

[17] Value-added (subtracting materials from output) production function would lead to biased estimates unless the elasticity of substitution between materials and other inputs is zero (Basu and Fernald, 1997).

vector of farm household level control variables that vary by season and year but not across plots such as the total amount of owned, sharecropping and fixed-rent land cultivated. This is to account for the fact that a farm household cultivating multiple plots may allocate scarce inputs across plots that maximizes total farm profits but not necessarily plot-level profit. **W** is a vector of plot-specific control variables that include dummies for soil types, land elevation, provisions for irrigation and plot-specific shocks, such as insecticides, hailstorms, droughts or floods.

5.2 Identification strategy

The endogeneity of contract choice arises because of unobserved farmer characteristics such as risk preference and productivity, unobserved market imperfections leading to suboptimal inputs combination and plot size (size-productivity relationship) and its characteristics such as soil quality, all are likely to differ across farmers.

Tenancy contract acts as both an incentive device and a self-selection device to identify the characteristics of different tenant farmers (Newbery and Stiglitz 1979). In the absence of insurance market, a less (more) risk-averse tenant will prefer a fixed-rent (sharecropping) contract. A more productive tenant will also opt for a fixed-rent than a sharecropping contract.

From a farm household optimization problem, equilibrium TFP can be expressed as proportional to a combination of output and input prices that differs across farmers depending on different degrees of imperfections they encounter in these markets. This leads to a suboptimal input combination, which in turn affects TFP.

There is a burgeoning literature that uses micro-level data to provide macroeconomic evidence of a positive relationship between plot (farm) size and TFP in agriculture both across and within countries (Adamopoulos and Restuccia, 2014; Chen et al., 2017; Restuccia and Santaeulàlia-Llopis, 2017; Adamopoulos and Restuccia, 2020). This finding contrasts the negative size-productivity (yield) relationship widely documented in the literature. If owner and tenant cultivated plots are significantly different in size (and quality), then their estimated TFP differential would be biased upward in the presence of the positive size-productivity relationship. The quality of land might also differ between owner and tenant cultivated plots; for example, a landowner might prefer to cultivate her better quality plots and rent out inferior quality plots (Dubois, 2002; Braido, 2006). Therefore, contract choice will depend on the quality of plots, which in turn affects TFP.

Our identification strategy relies on three important features in our data. First, we compare TFP in two plots cultivated by the same farm household, one owned and another rented-in under either sharecropping or fixed-rent contract. Second, we control for time-varying household fixed effects. Finally, we control for plot characteristics such as its size and land quality (soil type, land elevation and provision for irrigation). The first and second features account for any unobserved heterogeneity at the farmer level such as their ability and risk preference, and difference in suboptimal input allocation between owner and tenant cultivated plots due to market imperfections.[18] Quality of plots also accounts for the endogeneity of contract choice. Plot size accounts for the size-productivity relationship.

Therefore, the remaining variations in TFP between tenant and owner cultivation would be due solely to incentives.

6. Results

6.1 Marshallian inefficiency

The results estimated from equation (2) are presented in Table 4. Here, we use our benchmark measure of TFP calculated from the production function in equation (1) using the parameter values. Our attention is on the β_1 and β_2 coefficients, which estimate the TFP for sharecropping and fixed-rent, respectively, relative to owner cultivation. Col. (1) reports the results when all control variables specified in equation (2) including time-varying farm household fixed effects are included in the regression. The TFP is 4.2 percent lower on average in sharecropping than owner cultivation, and the coefficient is significant at any conventional level as shown by the large *t*-statistic. In contrast, there is no difference in TFP between fixed-rent and owner cultivation; β_2 is negative but statistically insignificant and very small in magnitude.

Insert Table 4 here

The results reported in cols. 2-6 are estimated using alternative combinations of some key control variables. In col. (2), time-varying farm household fixed effects are replaced by time-invariant farm household fixed effects and year fixed effects. In col. (3), household

[18] It is important to mention that tenurial contracts are more of social convention (focal point) in that all sharecropping contracts (such as, 50-50 or 2/3-1/3) or the amount paid to the landlord (cash or in kind) in a fixed-rent contract are the same in a village or even in a region (Bardhan, 1984; Young, 1996). Household fixed effects account for this (village fixed effects would be sufficient).

fixed effects are excluded. In col. (4), season fixed effect is excluded. In col. (5), rice variety is excluded. In col. (6), land quality and also plot-specific shocks are excluded. In all cases, the results are strongly robust. The TFP difference between sharecropping and owner cultivation ranges between 3.8 percent to 4.6 percent, and that between fixed-rent and owner cultivation remains insignificant and very small in magnitude. The results in cols. 2 and 3, in which household fixed effects are excluded, suggest that comparison of two plots cultivated by the same farm household, to a large extent, accounts for both unobserved farmer characteristics and market imperfections.

In all estimations, we find a positive and strong size-productivity relationship as shown by the coefficient on plot size, which supports the findings in the recent literature (Adamopoulos and Restuccia, 2014; Chen et al., 2017; Restuccia and Santaeulàlia-Llopis, 2017; Adamopoulos and Restuccia, 2020).[19] We argued in Section 5 that excluding plot size from the regression would upwardly bias the estimates of TFP differences because rented plots, both with and without adjusting for land quality, are significantly larger than owner cultivated plots (documented in Table 2). To verify this, we exclude plot size in col. (7); TFP now becomes six percent and 7.7 percent higher, respectively, in sharecropping and fixed-rent than owner cultivation.

Insert Table 5 here

We check robustness of our results using TFP estimated from alternative functional forms. The first approach estimates a log-linear version of the Cobb-Douglas production function in equation (1). The second approach estimates a second-order Taylor approximation of the CES production function as in Kmenta (1967). The final approach estimates a translog production function. These results, presented in Table 5, remain strongly robust, even the coefficient on sharecropping remains almost identical. The positive size-productivity relationship also remain robust although its magnitude is now about six times smaller. TFP

[19] The size-productivity relationship in the literature is based on the idea that yield is higher in small than large farms, where a farm is defined in terms of the total amount of land cultivated/owned by a farm household. The reason is that small farmers more intensively employ family labor in their farms that leads to higher yield (Otsuka, 2007). In contrast, our results of the size-productivity relationship is based on the definition of the size in terms of the area of a plot. There is a high positive correlation between farm size and plot size in Bangladesh. As discussed in Section 2.1, landholding in Bangladesh, even those of large landowners, is characterized by fragmented and spatially scattered small plots. Plots are divided among the family members (sons and daughters) after the death of their father. For a large farm household who owns a large amount of land in many different plots, this results in division of plots among family members without splitting plots. On the other hand, for a small farm household who owns a small amount of land in few plots, this results in splitting the plots into further smaller sizes.

calculated by the two alternative approaches—directly using parameterization (benchmark) and estimation of different functional forms—give different magnitudes of TFP,[20] which is manifest in the size-productivity relationship but the difference in TFP between owner and tenant cultivation remain almost identical.

6.2 Variation in input uses

After controlling for unobserved differences across farmers, such as ability and risk preferences, and market imperfections, the remaining difference in TFP between tenant and owner cultivation is due to difference in input use which results from incentives in tenurial contracts. To understand the reasons for TFP differences, the obvious step would therefore be to compare application of capital, material and labor inputs per unit of land. To explore this, we estimate the following equation similar to Shaban (1987; equation-7):

$$\ln(X/L)_{pist} = \alpha + \eta_{it} + \gamma_s + \beta_1 S_{pist} + \beta_2 F_{pist} + \delta_2 RV_{pist} + \mathbf{\Psi}'\mathbf{V_{ist}} + \boldsymbol{\psi}'\mathbf{W_{pist}} + \varepsilon_{pist} \quad \text{---(3)}$$

Here, X/L is input X per unit of land, where X is labor, capital and material inputs. When the input is labor, especially disaggregated by family and hired labor, and peak and off-peak periods, we estimate additional specifications, in which the dependent variable is the ratio without logarithm, and also treating it as binary (if X/L > 0 or not).

Insert Table 6

The results are presented in Table-6. Only 1.8 percent less capital is used in sharecropping than owner cultivation and the difference is significant only at the 10% level. Such a difference in material input use is 3 percent. There is no differences between fixed-rent and owner cultivation in the use of these two input; the coefficients are positive but very small and statistically insignificant (col. 1 and 2). In contrast, about 12 percent less labor, on average, is employed in sharecropping than owner cultivation (col. 3). Importantly, 8.4 percent less labor is also employed in fixed-rent than in owner cultivation. Therefore, it is mainly labor than other inputs that is employed more intensively in owner than in tenant cultivation. In terms of person days per acre of land, these are 5.4 and 3.8 less in sharecropping and fixed-rent than owner cultivation, respectively (col. 4).

[20] The minimum correlation between TFPs calculated directly using parameterization and estimated from different functional forms is 0.88, and the correlation among those estimated from different functional forms are 0.99.

When labor is disaggregated by family and hired labor, about 6.6 person-days less of family labor per acre of land is employed in sharecropping than owner-cultivation (col. 5). In our data, family labor was employed in almost all plots (except only 24 out of 4,206 plots; therefore, there is no difference at the extensive margin among the three types of cultivators). In contrast, cultivation was done without employing any hired labor in 30.9% of the plots (using only family labor). When comparing whether any hired labor is employed in a plot, it is 4.3% and 5.1% fewer plots in sharecropping and fixed-rent than owner cultivation, respectively (col. 6). However, in the intensive margin (only the plots where any hired labor was used), there is no difference in person-days of hired labor employed among the three types of cultivators (col. 7). Therefore, it is mainly the family labor that is employed less intensively in tenant cultivation than owner cultivation.

The relative efficiency of family and hired labor even after accounting for the hiring and supervision costs is not settled (see the discussions in Roumasset and Lee, 2007). All households in our sample are farm households having members with long farming experience who are directly engaged in cultivation (see, Section 3 and Table 1). This suggests that family labor is more or at least as productive as hired labor. Labor is hired during the pick period for planting and harvesting when the amount of family labor is not enough to meet the labor demand. Family laborers have higher incentives to provide effort than hired laborers because they are residual claimants to profits (Deininger and Feder, 2001). This explains the less use of family labor in sharecropping compared to owner cultivation (and also fixed-rent cultivation).

The reasons for minimal difference in capital and material inputs are the following. Capital service, which largely consists of mechanical tilling by power-tillers, is purchased from external service providers. Given the indivisibility of mechanical tilling and lack of capital-labor complementarity in it, there is almost no difference in capital use per unit of land between owner and tenant cultivation. Material inputs are subsidized by the government, but their application is highly labor intensive (Footnote 8 in Section 2.1). Less intensive use of labor in sharecropping is the reason for the modest difference in the use of material inputs. Less intensive use of inputs, particularly labor, in sharecropping explains its lower TFP than owner cultivation. Only labor is less intensively used in fixed-rent than owner cultivation but not as much in sharecropping and there is also no difference in the use of capital and material inputs. This is perhaps the reason for no difference in TFPs between owner and fixed-rent cultivations.

6.3 Yield as the measure of farm productivity

Although our focus is to compare TFP in sharecropping with owner cultivation and fixed-rent, the Marshallian inefficiency has been formulated and tested by comparing yields. Now we replicate our benchmark results using yield as the measure of productivity for comparison. The results are presented in col. 4-5 in Table 5. The specification in col. 4 is identical to our benchmark specifications (col. 1 in Table 4), where all control variables including the fixed effects and plot size and its characteristics are included. The results are very similar in that the coefficient on sharecropping is almost identical to that obtained for TFP, and the coefficient on fixed-rent is insignificant and close to zero although changes its sign to positive. However, there are two important differences from previous results; the coefficient on plot size is now insignificant (*t*-statistic is only 0.51) and is close to zero, and the coefficients on sharecropping and fixed-rent do not change if plot size is excluded (col. 5).

As mentioned earlier, our identification strategy of comparing two plots cultivated by the same farm household and controlling for household fixed effects account for sub-optimal input combinations, but in the case of yield as the dependent variable another omitted variable is returns-to-scale. If returns-to-scale does not vary across tenant and owner cultivation, omitting this from the regression would not cause any difference in the respective coefficients on sharecropping and fixed-rent but this omission will bias the coefficient on plot size. We cannot compare with and without controlling for returns-to-scale, but we compare excluding household fixed effects that, to a large extent, account for sub-optimal input combinations. The coefficient on plot size now changes to negative although remains insignificant (col. 6). Comparing with the results for TFP using the same specification (col. 3 in Table 4) in which the coefficient on sharecropping decreased to -0.044 from the benchmark at -0.042, it now increases by 24% from -0.041 to -0.032.

We try to get a sense why the magnitudes of the coefficient on sharecropping do not vary much for the two measures of productivity in our data. TFP can be expressed as the sum of average products of all inputs multiplied by their respective input shares (i.e., marginal products), while yield is the average product of land. Given that the difference in the intensity of input use between sharecropping and owner cultivation emanates mainly from labor use, which is about 12%, and the labor share in production is set at 0.14, the unconditional mean difference between TFP and yield would be less than 2 percent.[21] Therefore, we do not find any meaningful differences in our data but it does not justify the use of yield for the comparison of productivity across farmers.

We cannot place our main results of the TFP differences in relation to other studies in the literature because of the lack of comparable results. However, the yield difference of 4.1% may be large as we study rice monocropping. Hayami and Otsuka (1993), based on an extensive literature review, document that mean differential in yields between owner cultivation and sharecropping is due mainly to the differences in the production function and that becomes insignificant once comparison is made in terms of monocropping.

6.4. Output gain from reallocation

The inefficiency of sharecropping leads to misallocation of resources that has been raised as early as Sen (1966). This implies that elimination of this inefficiency would lead to an increase in aggregate output, an exercise that we undertake in the following.

Based on the production function in equation (1) expressed in terms of output-land ratio (yield), we calculate the average gain of output per unit of land (yield) if sharecropping and fixed-rent plots were cultivated by owner cultivators. We use the estimated differences in TFP and the use of labor, capital and material inputs (col. 1 in Table 4; cols. 1-3 in Table 5).[22]

For the benchmark parameter values of the returns-to-scale and input shares discussed in Section 4, the average yield gain if resources were reallocated from sharecropping to owner cultivation is 5.7%. The same for reallocation from fixed-rent to owner cultivation is only 1.1%. These values, especially the one for sharecropping, are sensitive to the choice of the value of the returns-to-scale. For example, if CRS is assumed (and the input share parameters are adjusted accordingly), the yield gain for reallocation from sharecropping increases to 6.7%, while that for fixed-rent increases only to 1.3%. In contrast, if the returns-to-scale is assumed to be 0.75, the corresponding gains are 4.7% and 0.09% for sharecropping and fixed-rent, respectively. In our estimation, we obtained 4.1% yield difference (col. 4 in Table 5), the number is obtained for returns-to-scale equals 0.65.

[21] When we estimate the linearized version of equation-1 (for calculating alternative measure of TFP), the estimated labor share becomes 0.07. Using this value of the labor share, this difference would be even smaller.
[22] For example, we use k^O/k^S = 1.018, n^O/n^S = 1.12, m^O/m^S = 1.03, where lower-case letters refer to the respective input per unit of land, and O and S superscripts refer to owner cultivation and sharecropping, respectively.

Using the information that in Bangladesh the total amount of land under rice cultivation is 2.8754 million acres (Table: 2.1.1, BBS, 2024), the share of rented-in land in total cultivated land is 45% (Sen et al., 2023) and the fraction of land under sharecropping among all tenants is 41.3% (Hossain, Malek and Das, 2014), the amount of land cultivated under sharecropping would be around 5,344 (= 28,754*0.45*0.431) thousand acres. The amount of land cultivated under fixed-rent would be around 3,080 (= 28,754*0.45*0.238) thousand acres.

At the rate of 1,362 kg of rice produced per acre (Table: 2.1.1, BBS, 2024), the total amount of rice production can be increased by 77.63 (=1,362* 0.057) kg per acre by reallocating resources from sharecropping to owner cultivation, which leads to an increase of a total of 414,876.096 MT. This is about 1.1% of total rice production (of 39,095 thousand MT) in Bangladesh. The corresponding total amount of increase in rice production for reallocation from fixed-rent to owner cultivation is 4,614.456 MT, which is about one-ninth of that for sharecropping.

It is important to mention that although inefficient, sharecropping can be an equilibrium outcome in the agrarian economy in the presence of market imperfections and information asymmetry.

7. Marshallian inefficiency in the presence of surplus labor

A profit-maximizing farm household will allocate scarce resources to plots where the retained marginal returns are the highest. This is the reason for less input intensity, especially labor, in sharecropping because sharecroppers retain a fraction of surplus from additional inputs. However, this analysis is based on the premise that the marginal return of labor is equated with market wage which is the same as the shadow wage of family labor. However, if the shadow wage decreases with the labor endowment in the household, sharecroppers having larger labor endowment will exert more labor. This will in turn be reflected in their TFP. Therefore, the differences in TFP and labor use per unit of land will be decreasing with the surplus labor in the household.

Empirical investigation of the above argument is challenging because of the lack of a workable definition of surplus labor. Pioneered by Lewis (1954) and later followed by Sen (1966), among others, surplus labor is defined as the part of the labor force in an agrarian economy that can be removed without reducing the total amount of output produced, even when the amount of other factors is not changed. Sen (1966; p. 428-429) further stated the necessary condition for the existence of surplus labor is that “a fall in the number of working members should be compensated by a rise in the amount of work done per person." Given this difficulty of finding an empirical counterpart of the definition of surplus labor, we follow an indirect approach by examining any change in the difference in TFP and labor employment per unit of land between sharecropping and owner cultivation as the labor endowment in the farm household increases.

Following Chay and Munshi (2015), we estimate the following equation.

$$\ln TFP_{pist} = \alpha + \eta_{it} + \gamma_s + \beta_1 S_{pist} + \beta_2 F_{pist} + \tau(D_i \leq \overline{D}) + \theta_1(D_i \leq \overline{D}) * S_{pist} + \theta_2(D_i \leq \overline{D}) * F_{pist} + \delta_1 \ln L_{pist} + \delta_2 RV_{pist} + \mathbf{\Psi}'\mathbf{V_{ist}} + \mathbf{\psi}'\mathbf{W_{pist}} + \varepsilon_{pist} \quad \text{---(4)}$$

Here $D_i \leq \overline{D}$ is a dummy variable equals 1 if the amount of labor endowment in the farm households does not exceed $\overline{D}$ and 0 if exceeds. The β_1 coefficient estimates the TFP difference between sharecropping and owner cultivation for the benchmark category, that is for the farm households for which the labor endowment exceeds $\overline{D}$ $(D_i > \overline{D})$.[23] We estimate β_1 for all values of $\overline{D}$ in the data range and evaluate how its statistical significance changes as $\overline{D}$ increases. The non-existence of the Marshallian inefficiency will be supported if β_1 becomes statistically insignificant at some threshold value of $\overline{D}$ and remains so beyond the threshold.

We alternatively consider two proxies for labor endowment by the number of working-age members aged between 15-65 years: i) male working-age members and ii) gender-adjusted working-age members where each female is counted as 0.1 male equivalent, which is based on the pattern of female labor use in rice cultivation in Bangladesh.

In Bangladesh, the shares of female and male labor use in the cultivation of local variety of rice are 11.7% and 88.3%, respectively. These shares are 11% and 89%, respectively, for modern variety of rice (Rahman, 2000). The female labor almost entirely consists of family labor; the shares of female hired labor in total hired labor are only 1.9% and 2.3% for local and modern variety of rice, respectively (calculated from Table 1 in Rahman, 2000).[24] We therefore assign 0.1 male-equivalent to a working-age female to calculate gender-adjusted labor endowment.

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[23] Note that τ will not be estimated as $(D_i \leq \overline{D})$ will be dropped in estimation because it is captured by household fixed effects. Even time-invariant household fixed effects would not capture it as the number of working-age members remain almost the same over two years. Its interactions with tenurial contracts (sharecropping and fixed-rent) are plot specific, which estimate the difference with owner cultivation (θ_1 and θ_2).

[24] Rahman's estimates are based on a comprehensive survey in 1989. The author documented that female labor in crop production is highest in vegetable (47.7%) followed by pulses and (27.5%), spices (21.8%) and oilseeds (21.1%).

There is some indirect support of very low level of female participation in crop production in our data. Crop production is the primary occupation for 55% of working-age male, while it is only 1.03% for working-age female (household activity is the primary occupation for 84.66% of the female).[25] Of those working-age male who have a secondary occupation (46.7%), 70% of them have crop production as their secondary occupation. The latter group of male members engage in crop production to support their farm households when the demand of labor is high, especially in the peak period. Therefore, it is not unreasonable to assume that most of the male working-age household members are engaged in crop production to some extent depending on the seasonality in labor demand. The corresponding number for the female is 38% (of only 7.1% of the working-age female who have a secondary occupation) but they are traditionally engaged in post-harvest crop processing but not in direct cultivation and harvesting. It is important to mention that female participation in broad agriculture in Bangladesh is high but that mostly consists of livestock and poultry rearing, which are also their part-time activities.

Figure 1 plots the *t*-statistics of β_1 against the number of male working-age members greater than $\overline{D}$. A specific value of $\overline{D}$ on the horizonal axis indicates that a farm household having labor endowment of more than $\overline{D}$ number of working-age male members. The endowment ranges between 0 to 5 in the data.[26] The figure shows that the negative value of the *t*-statistics gradually decreases in absolute value with the endowment and becomes statistically insignificant (at any conventional level) at $\overline{D}$ equals three and remains so beyond that. When the number of gender-adjusted working-age members is considered as the proxy for labor endowment, we observe the same decreasing pattern of the *t*-statistics of β_1 that becomes insignificant at $\overline{D}$ equals 3.3 and remains so beyond that (Figures 2).[27]

Insert Figures 1-2 here

[25] Jaim and Hossain (2011) documented that in Bangladesh only 3.85% of the female workers participated in crop farming in 2008 compared to 53% for the male. Crop farming was a relatively full-time activity for the participating female (which is also consistent with our data in terms of occupation) and they allocated 2.92 hours per day in 2008.

[26] The number of male working-age members ranges between 0 and 7 in our data. There are only a few households with more than 5 male working-age members, so we do not plot beyond 5. There are around 1.9 percent households with no male working-age members but they have male members outside the 15-65 age range.

[27] The same threshold values are obtained in the case of yield.

To investigate how the intensity of labor use changes with labor endowment, we estimate the following equation, similar to equation (4), and plot the *t*-statistics of the β_1 coefficient against labor endowment.

$$\ln(\mathrm{N/L})_{pist} = \alpha + \eta_{it} + \gamma_s + \beta_1 S_{pist} + \beta_2 F_{pist} + \tau(D_i \leq \overline{D}) + \theta_1(D_i \leq \overline{D}) * S_{pist} + \theta_2(D_i \leq \overline{D}) * F_{pist} + \delta_2 RV_{pist} + \mathbf{\Psi}'\mathbf{V_{ist}} + \boldsymbol{\psi}'\mathbf{W_{pist}} + \varepsilon_{pist} \qquad \text{-----(5)}$$

Our first case is the ratio of total labor to land. Figure 3 shows the *t*-statistics of β_1 when the labor endowment is proxied by the number of male working-age members. As in the case of TFP, the (absolute) negative value of the *t*-statistic gradually decreases with the endowment and becomes insignificant at $\overline{D}$ equals four and remains so beyond that. The threshold for the gender-adjusted working-age member is 4.1 (Figure 4). A similar pattern of gradual decreasing of the *t*-statistic is also observed for the ratio of family labor to land. For male and gender-adjusted working-age members, the thresholds are four and 4.4, respectively (Figures 5 and 6).

Insert Figures 3-6 here

Combining these results with the previous results for TFP, it can be concluded that the Marshallian inefficiency, which is due mainly to less intensive use of the labor, ceases to exist in the presence of surplus labor in the farm household.

8. Concluding remarks

In this paper, we explore the existence of the Marshallian inefficiency and, if exists, whether it disappears when there is a surplus labor in the farm household. We estimate the difference in TFP between owner and tenant cultivation in rice monocropping in Bangladesh. Using a farm household level panel data at the plot level and employing a novel identification strategy to account for unobserved farmer heterogeneity, we find the TFP is 4.2% lower in sharecropping than owner cultivation. There is no difference between fixed-rent and owner cultivation. The main reason for lower TFP in sharecropping is less intensive use of labor, particularly family labor; differences in the use of material (intermediate) inputs and capital are much smaller. Labor is also less intensively used in fixed-rent but not as much as in sharecropping.

We also find that the difference in labor intensity per unit of land, and consequently difference in TFP between sharecropping and owner cultivation, ceases to exist when the labor endowment is large in the farm household. In conclusion, our results support the Marshallian inefficiency hypothesis and contradicts the monitoring approach and indicate that this inefficiency disappears in the presence of surplus labor.

Changes in the agrarian relationship in Bangladesh (see Section 2.1), mechanization in capital services and introduction of modern varieties (HYV) have played important roles in influencing the Marshallian inefficiency. Mechanized capital has substituted manual tilling and threshing, and also harvesting to some extent, which are done in the peak period. Therefore, the demand for labor in the peak period has decreased. On the other hand, introduction of HYV has increased the demand for labor for activities such as weeding, application of fertilizer and pesticides, and irrigation, which are done in the off-peak period. The net effect on labor demand is not determined. Introduction of HYV has increased considerably the use of material inputs, (some of) which are subsidized by the government and farmers of all types have access to these inputs. Because of these developments, the difference in the use of capital and material inputs between sharecropping and owner cultivation is lower than before. The overall effect would be to lower the TFP differential.

The evolution of surplus labor in rural Bangladesh is influenced by two opposing effects—change in demography and increased opportunity for non-farm activities in rural areas. Over the 1988-2004 period, the average household size in rural areas has decreased from 5.86 to 5.25, but the share of members aged between 15 and 64 years has increased from 53.2% to 62.5%. Given this change in the demographic pyramid, the average number of household members aged between 15-64 years has slightly increased from 3.12 to 3.28 although the average number of male members in the same age range has remained almost the same at around 1.62 (calculated from Tables 3.1a and 3.2 in Hossain and Bayes, 2009). These demographic changes have some, although not large, positive effect on the labor endowment in rural households.

In contrast, improvement in rural infrastructure such as all-weather road and electrification has created opportunities for non-farm activities, which has decreased the amount of household labor endowment for agricultural activities. The net effect of these two opposing effects is likely to be a decrease in surplus labor. However, household members engaged in non-farm economic activities also engage in agricultural activities in the peak period when labor demand is high. Counting these members would probably have no effect on the amount of labor endowment for agricultural activities. Therefore, the role of surplus labor influencing the Marshallian inefficiency is still no less relevant than before.

There is a gradual, although slow, increase in mechanization in crop including rice cultivation in Bangladesh. Further mechanization in the activities of planting and harvesting that would considerably decrease the demand for labor will have effect on the Marshallian inefficiency.

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Tables and Figures

Table 1: Comparison of sample farm households with the population (census).

	Population	BCUP eligible	Difference
Age of the farmer	46.551	42.714	-3.837*** (0.169)
Years of schooling of the farmer	4.121	3.017	-1.104*** (0.052)
Years of farming experience of the farmer	23.774	22.114	-1.660*** (0.192)
Household Size	4.786	4.956	0.170*** (0.025)
Amount of cultivable land owned (decimal)	33.844	37.861	4.018*** (1.220)
Amount of rented-in land for cultivation (decimal)	28.19	55.381	27.191*** (1.975)
Amount of land cultivated (owned + rented-in – rented-out) (decimal)	62.033	93.242	31.209*** (2.415)
N	61,322	7,563	

Figures in parentheses are standard errors. *** p<.01

Table 2: Plot size for different types of tenants.

	(1)	(2)	(3)	(4)
	Plot size (in decimal)			Plot size (log)
Sharecropper	14.224***	14.194***	14.658***	0.468***
	(14.792)	(14.916)	(15.178)	(18.155)
Fixed renter	12.169***	12.042***	11.304***	0.376***
	(11.339)	(11.372)	(10.090)	(12.745)
Constant (owner cultivator)	26.193***	30.748***	25.699***	3.113***
	(52.735)	(10.162)	(7.687)	(36.630)
Adjusted R2	0.084	0.098	0.393	0.422
N	4,206	4,206	4,206	4,206

Cols. 1 and 4: No control; cols. 2 and 5: control for soil type, land elevation, provision for irrigation, season and year fixed effects. cols. 3 and 4: Additionally control for farmer-year fixed effects. Robust clustered at farmer level *t*-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Rice variety (1 = modern; 0 = local) cultivated by different types of tenants.

	(1)	(2)	(3)
Sharecropper	0.056***	0.046***	0.012
	(5.853)	(4.298)	(1.599)
Fixed renter	-0.072***	-0.048***	-0.018**
	(-5.575)	(-3.875)	(-2.048)
Constant (owner cultivator)	0.770***	1.001***	1.076***
	(76.899)	(19.360)	(6.680)
Adjusted R2	0.011	0.202	0.625
N	4,206	4,206	4,206

Col. 1: No control; col. 2: control for plot size, soil type, land elevation, provision for irrigation, total amount of land cultivated, season and year fixed effects; col. 3: Additionally controls for farmer-year fixed effects. Robust clustered at farmer level t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Efficiency of tenant cultivation—DV: log of TFP.

	(1)	(2)	(3)	(4)	(5)	(6)
Sharecropper	-0.042***	-0.039***	-0.044***	-0.045***	-0.044***	0.051***
	(-4.329)	(-3.546)	(-4.316)	(-4.627)	(-4.546)	(5.160)
Fixed renter	-0.007	-0.004	-0.005	-0.005	-0.003	0.071***
	(-0.865)	(-0.442)	(-0.489)	(-0.553)	(-0.330)	(7.152)
Plot size (log)	0.203***	0.197***	0.201***	0.204***	0.196***	
	(23.118)	(19.712)	(22.028)	(23.260)	(22.485)	
Modern rice variety	0.251***	0.251***	0.280***	0.231***	0.237***	0.238***
	(9.392)	(10.359)	(15.202)	(7.890)	(8.091)	(8.168)
Constant	1.548***	1.580***	1.657***	1.907***	1.811***	2.462***
	(15.759)	(24.194)	(23.441)	(21.067)	(21.432)	(31.723)
Adjusted R^2	0.592	0.517	0.350	0.576	0.557	0.508
Within R^2	0.317	0.306		0.290	0.253	0.172
Season FE	Yes	Yes	Yes	No	Yes	Yes
Year FE	NA	Yes	Yes	No	NA	NA
Farmer FE	NA	Yes	No	No	NA	NA
Farmer-year FE	Yes	No	No	Yes	Yes	Yes
N	4,206	4,206	4,112	4,206	4,206	4,206

Robust clustered at farmer level t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions except col. 5 control for soil types, land elevation, provision of irrigation and plot-specific shocks.

Table 5: Efficiency of tenant cultivation—DV: Alternative measures of TFP and yield.

	(1)	(2)	(3)	(4)	(5)	(6)
	DV: log TFP (CD)	DV: log TFP (CES)	DV: log TFP (Translog)	DV: log Yield	DV: log Yield	DV: log Yield
Sharecropper	-0.043***	-0.042***	-0.042***	-0.041***	-0.039***	-0.032***
	(-4.441)	(-4.412)	(-4.349)	(-4.252)	(-4.546)	(-3.280)
Fixed renter	-0.007	-0.009	-0.012	0.001	0.003	0.003
	(-0.784)	(-0.973)	(-1.320)	(0.098)	(0.305)	(0.314)
Plot size (log)	0.036***	0.037***	0.035***	0.004		-0.010
	(4.118)	(4.133)	(3.852)	(0.507)		(-1.075)
Modern rice variety	0.188***	0.184***	0.181***	0.302***	0.302***	0.346***
	(6.428)	(6.356)	(6.309)	(10.117)	(10.125)	(18.525)
Constant	-0.167*	-0.228***	-0.227**	2.584***	1.904***	1.821***
	(-1.867)	(-2.589)	(-2.576)	(24.160)	(18.467)	(36.462)
Adjusted R^2	0.460	0.454	0.449	0.659	0.659	0.470
Within R^2	0.099	0.096	0.093	0.447	0.447	0.472
Season FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Farmer FE	N/A	N/A	N/A	N/A	N/A	No
Farmer-year FE	Yes	Yes	Yes	Yes	Yes	N/A
N	4,206	4,206	4,206	4,206	4,206	4,206

Notes: TFP-CD: Based on the estimation of log of the Cobb-Douglas production function. Robust clustered at farmer level t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions except cols. 1-3 control for soil types, land elevation and provision of irrigation (these variables were used to estimated TFP using quality adjusted land).

Table 6: Input per unit of land

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ln(capital/ land)	ln(material inputs/ land)	ln(labor/ land)	Labor/ land	Family labor/ land	If hired labor used	Hired labor/ Land
Sharecropper	-0.018*	-0.030***	-0.120***	-0.054***	-0.0663***	-0.043***	0.0035
	(-1.826)	(-2.812)	(-10.067)	(-9.682)	(-12.0904)	(-4.843)	(0.8564)
Fixed renter	0.012	0.002	-0.084***	-0.038***	-0.0467***	-0.051***	0.0053
	(1.061)	(0.191)	(-6.398)	(-5.687)	(-7.0911)	(-4.631)	0.0035
Constant	4.412***	1.285***	-1.049***	0.407***	0.3749***	0.165*	0.0830
	(25.345)	(5.873)	(-10.163)	(7.866)	(12.2130)	(1.786)	(1.4377)
Adjusted R^2	0.834	0.812	0.755	0.685	0.6521	0.293	0.7485
Within R^2	0.772	0.531	0.167	0.131	0.124	0.0269	0.0710
Farmer-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4,206	4,206	4,206	4,206	4,206	4,206	2,753

Notes: All controls except plot size. Col. 5: We retain the 24 plots which used no family labor—no difference if these are dropped. Col. 6: If the full sample is retained (with 0's for no hired labor), the coefficient (t-statistics) for sharecropping is 0.012 (3.786), and for fixed-rent is 0.008 (1.920), which imply that tenant (fixed-rent) cultivation uses 1.2 (0.8) person-days of more hired labor per acre of land.

Figure 1: The effect of surplus labor on TFP: *t*-statistics of β_1 (coefficient on sharecropping) by the number of male working-age members.

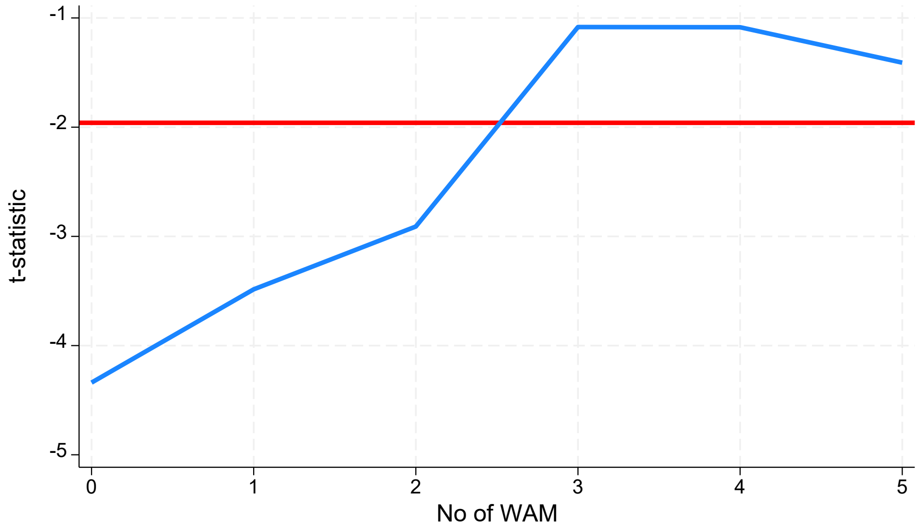

Figure 2: The effect of surplus labor on TFP: *t*-statistics of β_1 (coefficient on sharecropping) by the number of gender-adjusted working-age members.

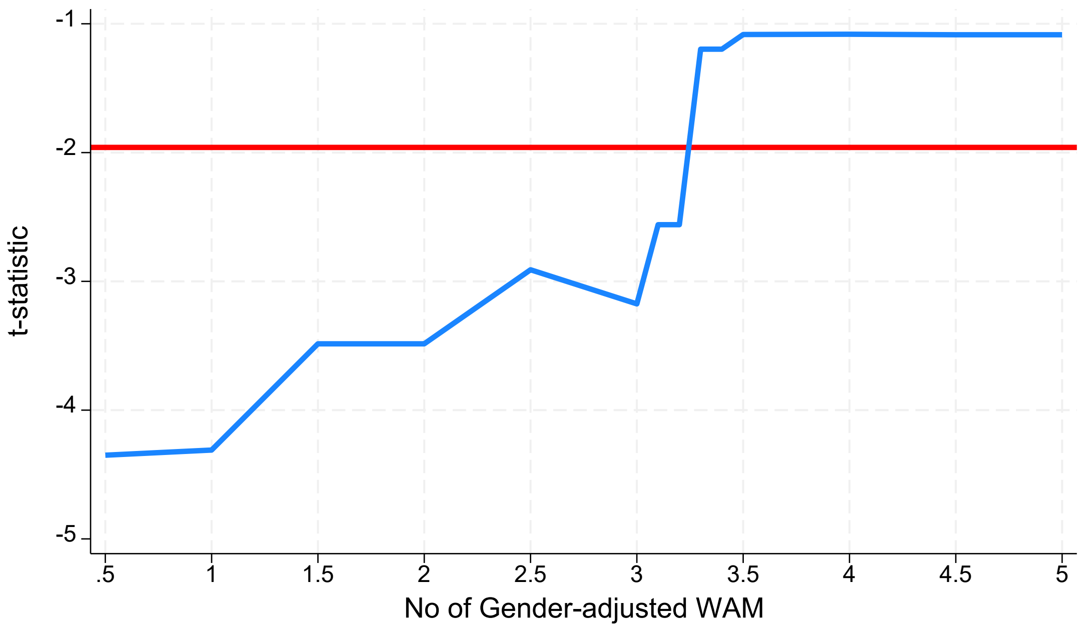

Figure 3: The effect of surplus labor on labor-land ratio: *t*-statistics of β_1 (coefficient on sharecropping) by the number of male working-age members.

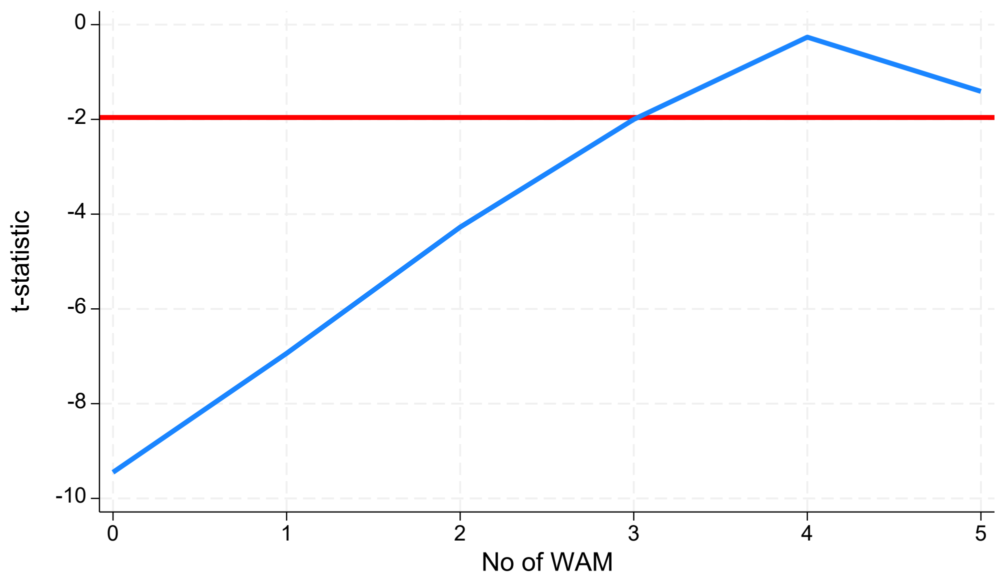

Figure 4: The effect of surplus labor on labor-land ratio: *t*-statistics of β_1 (coefficient on sharecropping) by the number of gender-adjusted working-age members.

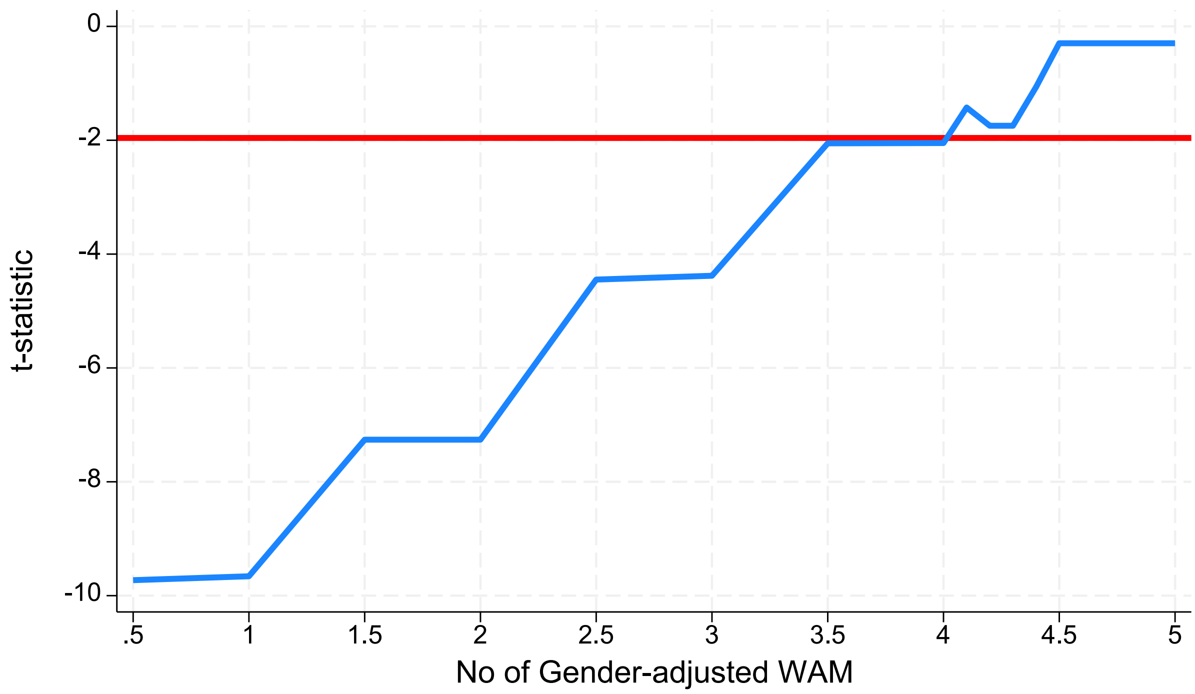

Figure 5: The effect of surplus labor on family labor-land ratio: *t*-statistics of β_1 (coefficient on sharecropping) by the number of male working-age members.

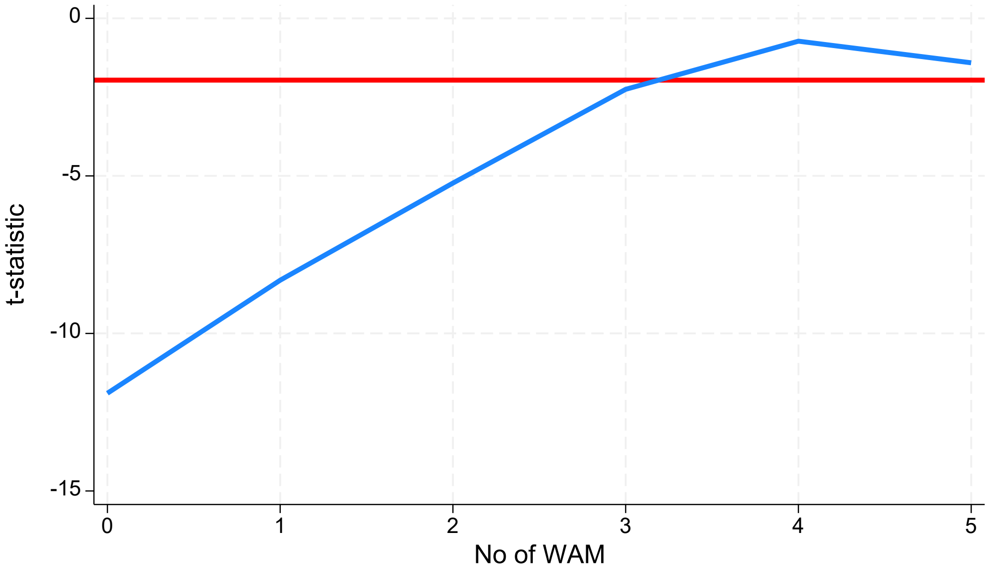

Figure 6: The effect of surplus labor on family labor-land ratio: *t*-statistics of β_1 (coefficient on sharecropping) by the number of gender-adjusted working-age members.